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THREE MUTATIONS IN PREVIOUSLY KNOWN LOCI

THREE mutations is the sex-chromosome have occurred in my cultures of *Drosophila melanogaster* (*ampelophila*). Two were reappearances of genes already known, namely, white and rudimentary; the third was the appearance of a new gene at the white locus and has been named coral, symbol w^{co}. In each case it is clear that the changes occurred in the wild type gene of a maternal chromosome. The evidence also indicates that the new gene arose relatively late in the history of the egg in each case, whereas if the mutation had occurred in the early oogonial stages several individuals with the new gene should have appeared. In cases where such information is known, it seems worth recording since it will make possible a later consideration of the relative stability of genes by a summing up of the frequency of mutations in the different loci.

As has been pointed out by Muller[1] recessive genes might exist for a long time before making an appearance, in case they were closely linked to a lethal. The character produced by the gene would ultimately be allowed to appear as the result of a cross over which would separate the gene and the lethal from the same chromosome. Previous to the time of crossing-over the character produced by the gene would never be seen, since all individuals pure for it would also be pure for the lethal and not survive. The gene could be indefinitely transmitted along with the lethal through heterozygous individuals. I mention this point because it is necessary in establishing the time of origin of a mutation to consider whether its appearance may be due merely to its recent separation from a lethal, which had obscured it. The three mutations dealt with here could not have been masked by a lethal because they were in the X-chromosome, and the presence of a lethal would have been apparent, as it would have produced a lethal sex ratio. No such lethal ratio has been found in connection with any of the three mutants either before or since their appearance. In these cases, then, it is safe to assume that the appearance of the first mutant marks the time of the mutation. If the mutation had occurred in earlier generations, several individuals bearing the character would have appeared instead of one.

In the case of the reappearance of a character, careful consideration must be given to the possibility of contamination, as has been pointed out by Morgan and Plough.[2] This possibility has been taken into account and is discussed with reference to the appearance of each gene in that particular section.

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[1] *Proc. Nat. Acad. Sci.,* Vol. 3.

ORIGIN AND DESCRIPTION OF CORAL

Coral arose in a mating of an eosin miniature bar-eyed male to a forked female with normal eyes. This female was a ''secondary exception'' from an XXY mother which had had no sex-linked eye color in her pedigree. Among 279 offspring that were of the expected classes and showed no lethal sex ratio, there was found about the middle of the count one heterozygous bar female which seemed to be ''exceptionally'' dark eosin. An eosin eye color in a female would be impossible to account for, since to be a female she must have obtained one of the mother's chromosomes, both of which carried normal red factors, as well as receiving the eosin bar chromosome of the father. A mating to one of her red-eyed brothers showed at once that the supposed eosin female was actually heterozygous for eosin and for a new allelomorph (coral) as she gave two kinds of sons, eosin and coral, while the daughters were eosin and the compound eosin-coral. The eosin-coral females are darker than pure eosin females and the original female was of this nature.

Coral is the seventh mutant allelomorph to be found in the white locus and counting the wild type gene forms with them a system of eight allelomorphs. In the order of their discovery these are: red, white, eosin, cherry, blood, tinged, buff and coral. Coral does not show bi-colorism, but is the same for males and females. It is similar to the color of very dark coral. It is darker than all the other members of this series with the possible exception of blood which according to the description of Hyde in his discussion of blood[3] shows a considerable variation of color according to cultural conditions. The color of coral is very close to the darker shades of blood, but is much darker than the lighter shades and does not show any such variations in range of color. Coral is distinctly darker than cherry and the other lighter members of this series. Coral is a dull color and does have the brightness of color of the wild stock, neither does it show the fleck in the eye.

The original coral female was re-mated to a white male from stock and behaved genetically, as would be expected on the assumption that coral was a member of the white allelomorphic series. The heterozygous white-coral compound in the female is intermediate in color between the two pure stocks. Coral is recessive to red. A coral male crossed to a yellow-white female gave all yellow-white sons and the intermediate (compound) white-coral daughters. Evidently the mutation took place in the wild-type gene of the mother, since it is that gene which did not occur in the daughter while the eosin gene of the father is retained. It also occurred near the maturation divisions as only one individual of the kind appeared. If the change had occurred in the early stages of the egg, it would probably have resulted in several of the offspring showing the new character.

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[2] AMER. NAT., Vol. 49.

[3] *Genetics*, 1, November, 1916.

Reappearance of White

In a cross of a bar male to a red-eyed female, which produced 251 offspring without a lethal sex ratio, one male was obtained which was white, although there was no white in the pedigree of either parent. This fly was found in one of the last counts of the bottle and had the appearance of being a young fly. Counts were made from the bottle every two days. Since I had no cultures going at that time which contained white and had had no white flies in my etherizing bottle previously, the fly can not be accounted for by assuming that it had remained in the etherizing bottle from a previous count of another bottle. It is highly probable, though not absolutely certain from these considerations that this white male was not due to contamination, but rather to a mutation in the wild type gene of a maternal chromosome. We may be sure that this change took place in the maternal chromosome rather than in that of the father, since males always receive their one X-chromosome from the mother except in relatively rare cases of non-disjunction, and in this case the male would have been bar.

In appearance the new white is not distinguishable from the white of the original stock and is quite without color in both males and females. Dr. A. H. Sturtevant has been testing the effect of various concentrations of alcohol in extracting color from the eyes of flies which are members of this multiple allelomorphic series and kindly added this new white to the material which he tested. He reported that the new white is acted upon exactly as is the original white. Genetic results showed the new white to behave as an allelomorph of the old. The new white male was crossed to a red sister and the offspring were all red.

The F_2 generation gave females all red and the males in equal classes of red and white, which is the genetic behavior expected for a sex-linked gene. To test whether this white was in the same locus as the old white, a white male of this stock was crossed to a yellow-white female from the original stock. The sons were yellow white and the daughters were white, not yellow, since yellow is recessive and was not carried by the father. No difference could be observed in eye color between either sex of the new white, or the daughters compounded from the two whites, and the males and females of the original white. It seems reasonable to conclude then that the white gene has reappeared by a second mutation from the red gene.

Second Origin of Gene for Rudimentary Wing

There appeared in a cross of an eosin miniature male to a broad, vermilion, forked female (both from stock cultures, all characters mentioned being sex linked) one son which was vermilion, forked like the mother, but which also had shortened wings. This wing character was later shown to be rudimentary. Crossovers in later generations showed that the maternal gene for broad was also present, but its effect was obscured by the rudimentary in all cases where both occurred together. This male so obtained and bearing genes for broad, vermilion, rudimentary and forked was outcrossed to a virgin wild type female to test whether the new character was of a genetic nature. The F_1 flies were normal in all respects. One pair of these produced 117 sons which were classified with respect to the characters vermilion, rudimentary and forked, while no attention was paid to broad, which did show in certain crossovers where it was separated from rudimentary. Out of 117 males, 3 were crossovers between rudimentary and forked, which gave a percentage of crossing-over of 2.6, whereas the value given by Morgan and Bridges[4] is 1.4 on the basis of a much larger number of flies. There were 27 crossovers between rudimentary and vermilion, which is a percentage of 22.2, while the above authors put it at 24.1. The nature of the crossovers obtained showed that the gene for the wing character was between vermilion and forked, which agrees with the assumption that it is a new appearance of rudimentary. The crossover values obtained are sufficiently near to expectation to justify this assumption in view of the small number of flies. Crosses were made to the stock rudimentary to make sure that the new gene was at the rudimentary locus. Since homozygous rudimentary females show a high degree of sterility, the rudimentary stock is kept by crossing it to forked and using normal-winged females that are heterozygous for both rudimentary and for forked. One of the new rudimentary males was crossed to such a heterozygous female and the new rudimentary was shown to be an allelomorph of the old, as both rudimentary sons and daughters were obtained in practically equal numbers. The new rudimentary stock resembled the old as regards the sterility of the homozygous females. Miss C. J. Lynch in this laboratory tested several and reported that they showed the same high degree of sterility. Since the new character has the same appearance as old rudimentary, this seems to be merely the reappearance of that gene.

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[4] Carnegie Pub. No. 237, 1916.

In this case it is clear that the change occurred in one of the maternal sex-chromosomes which already carried three sex-linked genes. The linkage relations of the new gene to these maternal genes make its origin in the maternal chromosome certain. Moreover, the male could have received his sex-chromosome only from his mother, as otherwise he would have been an XO male and would have been sterile.[5] The fly could not be accounted for on the assumption of contamination, as there are no flies of that particular constitution in the laboratory. The mutation was from the normal gene at the rudimentary locus. The appearance of only one individual indicates that the change occurred late in the history of the egg.

SUMMARY

1. Two mutations have occurred at the white locus in the normal red gene, giving rise to a reappearance of white and to a new gene which produces an eye color called coral.
2. Coral is the eighth member of the multiple allelomorph series at the white locus.
3. Rudimentary reappeared as a change from the normal gene at that locus in a maternal chromosome.

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[5] Bridges, *Genetics*, II, 1916.

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EVIDENCE FROM INSULAR FLORAS AS TO THE METHOD OF EVOLUTION

EVIDENCE as to the rôle which hybridization plays in evolutionary change may be obtained from various insular floras by a comparative study of the history of those plant types in them which are prevailingly self-fertilized and those which are prevailingly cross-fertilized, both as to the rapidity with which new local species are produced and as to the frequency with which old species disappear. With these points in view, analyses have been made of the vascular plants in the floras of eight islands or island groups: Ceylon, Mauritius, Socotra, New Zealand, Hawaii, Galapagos, Juan Fernandez and St. Helena.[1] In all these there is a conspicuous, often predominant, element in the flora which is strictly local or endemic, indicating that each island has been the theater of considerable evolutionary change.

Information is necessarily lacking as to the method of fertilization of most of the species, but our general knowledge of the reproduction of the higher plants allows us to divide them into three main types. The dicotyledons and petaliferous monocotyledons, possessing floral organs which in the great majority of cases are attractive to insects, are doubtless prevailingly cross-pollinated. In the glumaceous monocotyledons, on the other hand (chiefly Gramineæ, Cyperaceæ and Juncaceæ), the floral organs are not so constructed as to favor cross-pollination, and it will probably be agreed that crossing is much less common

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[*] These analyses are based on the following authorities: Trimen, Handbook of the Flora of Ceylon; Baker, Flora of Mauritius and the Seychelles; Balfour, Botany of Socotra; Cheeseman, Manual of the New Zealand Flora; Hillebrand, Flora of the Hawaiian Islands; Stewart, Botany of the Galapagos Islands; Johow, Flora de las Islas de Juan Fernandez; Melliss, St. Helena; and Hemsley, Report on the "Challenger" Expedition: Botany.